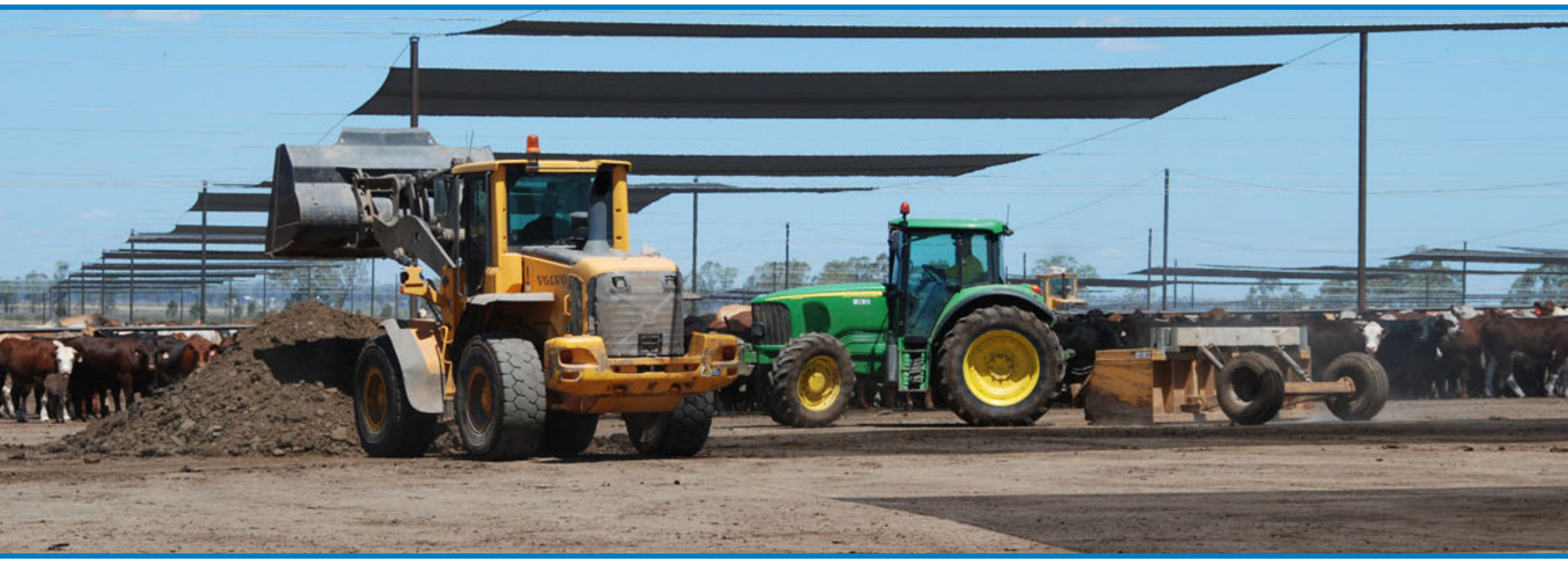
Department of Employment, Economic Development and Innovation

Integrated pest management for nuisance flies in cattle feedlots



Queensland Government

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Contents

Background

The feedlot industry has significantly improved manure management practices over the past decade, thereby reducing both odour and fly problems. However, flies continue to be a seasonal problem at many feedlots.

The impact of flies on production and animal and human health and welfare, as well as the threat of insecticide resistance and a desire to minimise chemical use underpin the development of a more integrated approach to fly control.

To achieve optimal fly control, several control methods should be used following integrated pest management (IPM) principles. IPM uses good sanitation, biological agents and the focused use of insecticides to reduce fly populations, rather than relying on insecticidal control methods alone.

Using IPM strategies to control nuisance flies in feedlots has many benefits for feedlot businesses, for the industry and for the environment and the community.

Individual feedlot businesses will benefit from implementing an IPM program to effectively control flies. Less flies means improved cattle welfare, reduced risk of disease transmission and potential production gains. Feedlot staff will enjoy better working conditions with less flies and less exposure to insecticides. There is also likely to be a reduction in complaints from neighbours about flies. Overall, the feedlot industry will also benefit because the risk of insecticide resistance in major fly species is reduced under an IPM program and the industry will be able to promote their 'clean and green' image and gain the associated market benefits.

The community and environment also benefit from widespread use of IPM to control flies in feedlots. Using IPM means there is lower risk of chemical residues in Australian feedlot beef and less nuisance flies on properties adjacent to feedlots. IPM has a positive impact on beneficial predators and parasites and reduces the negative environmental impacts of relying on chemical-only control methods.

Using this document

Part one of this document describes the physical attributes of the most common nuisance fly species found in feedlot environments. A pictorial identification key is provided. Knowledge of pest species and their natural enemies will help in implementing a targeted IPM strategy suitable for a specific cattle feedlot.

The second part of this document outlines the IPM approach to fly control and provides practical recommendations for feedlot design and sanitation, biological and insecticidal controls and fly population monitoring, based on recent research findings.

Finally, detailed information is provided about how to use parasitic wasps to control flies in feedlots. Parasitic wasps have become available in Australia only recently, providing an additional component for fly IPM.

Major nuisance flies in cattle feedlots

Key benefits

- Recognise key species of feedlot flies
- Understand aspects of fly biology relevant to the control of feedlot flies

The major nuisance flies in Australian feedlots are house flies, stable flies, bush flies and blowflies. These flies vary in their biology and behaviour, resulting in seasonal and locality differences in their respective populations. These differences must be considered when devising control strategies.

House flies and stable flies breed in non-compacted feedlot manure. Areas where fly breeding can be a problem include under fence lines, in sedimentation systems, drains and hospital areas. Bush flies breed in undisturbed animal dung and for this reason rarely breed in feedlots. However, adult bush flies can fly to feedlots from external breeding sites. Blowflies breed in animal carcasses and the normal management practice of completely covering these with manure or soil should eliminate blowfly breeding.

Adult flies

The four fly species found in the largest numbers on Australian feedlots are the house fly (*Musca domestica*), bush fly (*Musca vetustissima*), stable fly (*Stomoxys calcitrans*) and blowflies (species of *Chrysomya*, *Calliphora* and *Lucilia*).

The major feedlot fly species can be identified using a simplified pictorial key like the one provided in Figure 1. While most identification features can be observed with the naked eye, some form of magnification may help. Additional fly identification features are shown in Figure 2 (page 10).

Immature flies

Only a small percentage of the fly population may be in the adult stage and some, such as the bush fly, generally do not breed in feedlots. Major fly breeding sites in a feedlot include manure under the fence lines of pens and the hospital/induction area. The majority of immature flies found here are house flies, with smaller numbers of stable flies and occasionally other species.

Some features for identifying larvae are shown in Figure 2. The larvae of most feedlot flies are smooth in appearance, except for the hairy larvae of some blowflies and the little house fly (*Fannia canicularis*). Mature house fly larvae are conical, over 10 mm long and creamy white in colour. They have two dark mouth hooks at the narrow head end and two spiracular plates at the broad posterior end (Figure 2).

Biology of feedlot flies

The life cycle of the house fly is typical of the feedlot flies (Figure 3, page 10). The cycle consists of four stages: egg, larval, pupal and adult. Eggs are laid in batches of approximately 100 in suitable substrates such as manure. Each female lays several batches of eggs, producing over 500 offspring during her lifetime.

Larvae typically develop over four to seven days. On completion of feeding, the mature larva moves to drier and cooler areas, becomes inactive and uses the larval skin to form a dark brown protective case around the developing pupa. Once development is complete, the adult fly breaks out of the pupal case. After a few days the adults mate and the cycle starts again. The cycle from egg to adult can be completed in as little as seven days.

This short developmental period, and the large number of eggs produced per female, means that adult populations can build up rapidly. It has been estimated that 1 kg of manure can produce up to 10 000 flies. So, why aren't we knee-deep in flies?

Factors that limit fly numbers include the moisture content and temperature of the manure, seasonal influences, feedlot management practices and natural enemies such as predators and parasites.

To use this pictorial identification key, start with the box (marked 1, 2 or 3) most similar to the unknown fly then follow the arrows to identify.

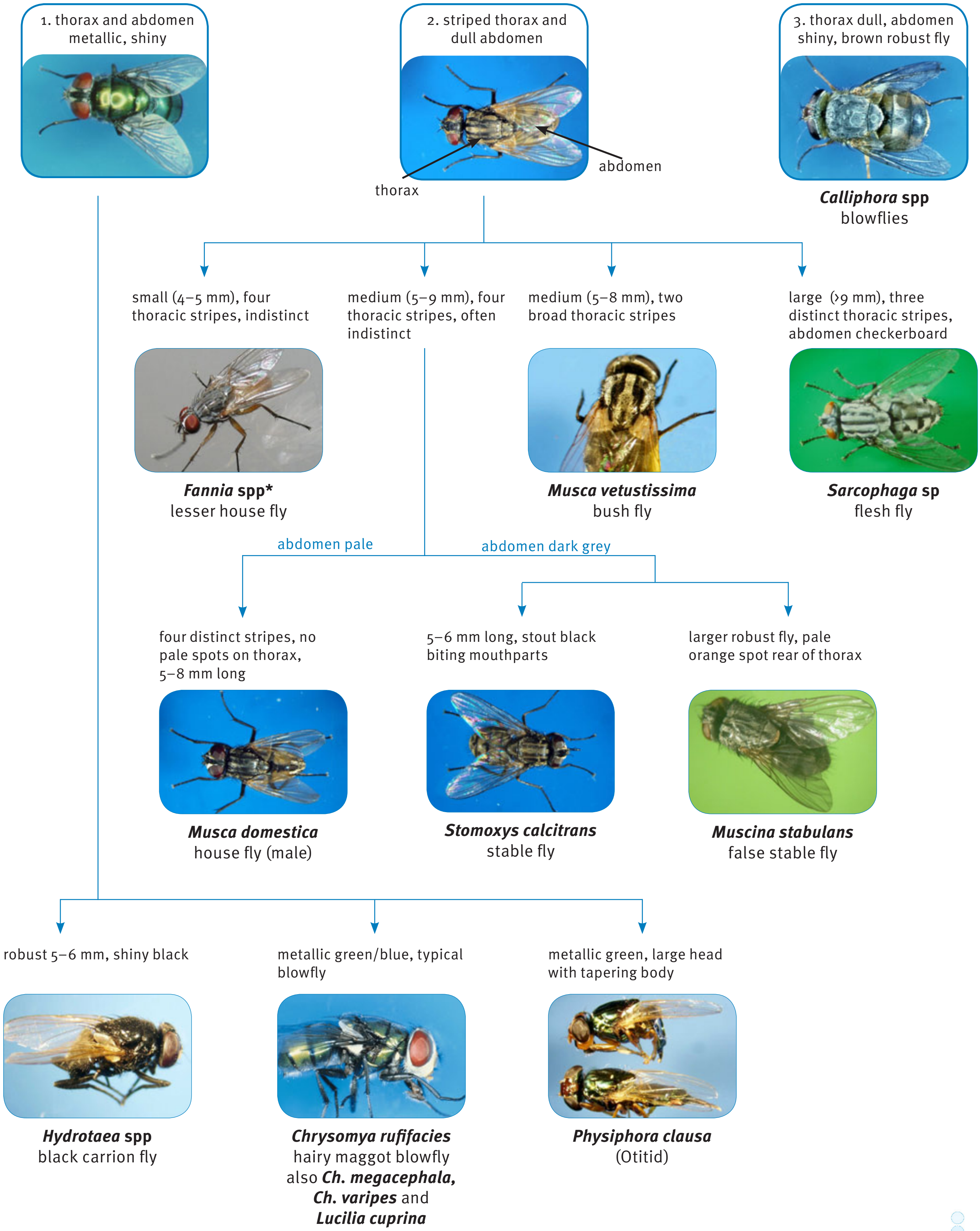

Figure 1. Pictorial key to common feedlot flies
*(*Source: http://commons.wikimedia.org/wiki/File:Mouche1-67000.jpg#globalusage)*

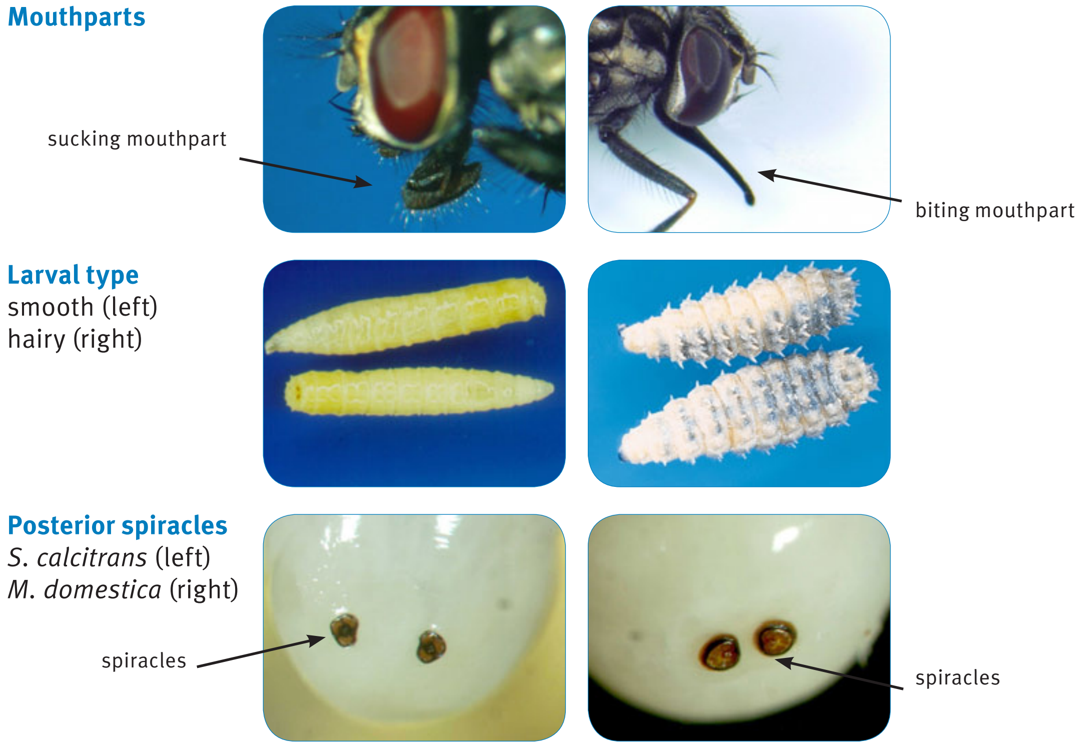

Figure 2. Additional identification features

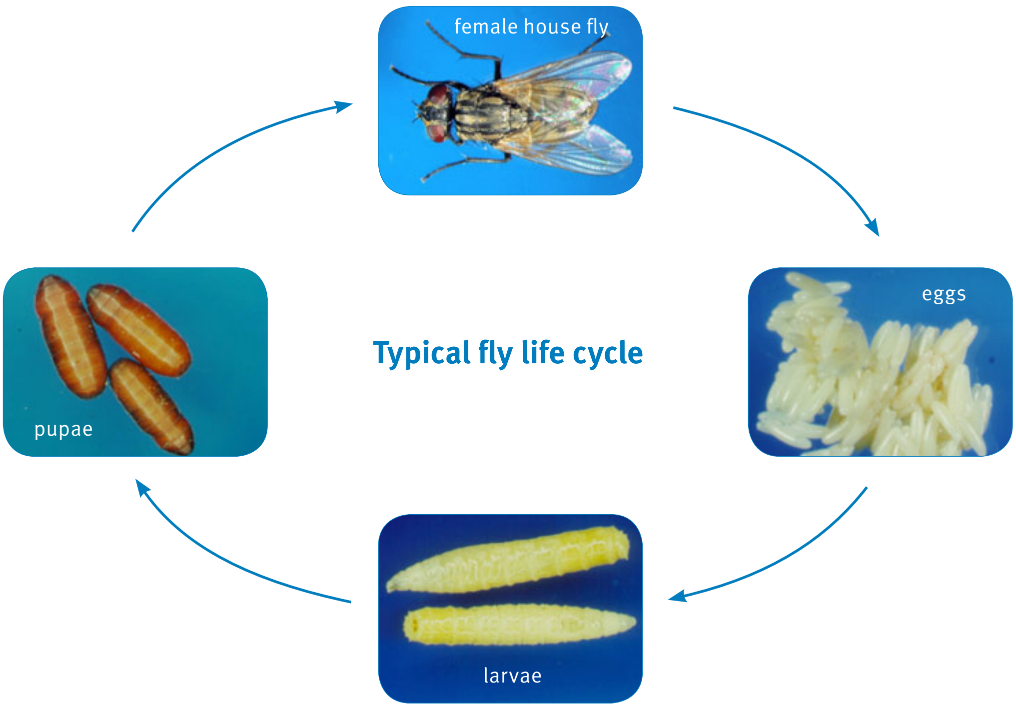

Figure 3. Fly life cycle

Natural enemies

Parasites, predators and other biocontrol agents present in manure and other feedlot habitats limit fly production. Naturally occurring biocontrol agents in Australian feedlots include parasitic wasps, insect-killing fungi, predatory mites, beetles, birds and ants. Parasitic wasps controlled 21–35% of nuisance flies in three monitored Australian feedlots.

Parasitic wasps

Eight species of wasps that parasitise a range of flies have been identified on Australian feedlots. Species of *Spalangia* are dominant; typically 70–90% of wasps belong to these species. These very small wasps (2–3 mm long) lay their eggs only in the pupal stage of nuisance flies (Figure 4). The female wasp drills a hole in the pupal case and either feeds on the contents or lays a single egg. A wasp larva hatches from the egg and feeds on the fly pupa, eventually killing it. After approximately three weeks, the adult wasp emerges through a small hole in the pupal case. These parasitic wasps attack the pupae of a number of feedlot flies and ignore other insects. Because of their small size the adult wasps are seldom noticed. They are harmless to people and livestock.

Figure 4. Spalangia endius *wasp on a house fly pupa*

Fungi

A number of microbial pathogens cause diseases that kill flies. The fungi *Metarhizium anisopliae* and *Beauveria bassiana*, isolated from house flies collected on Australian feedlots, show promise as biocontrol agents (Figure 5). Fungi are unique among the microbial insect pathogens in that they primarily infect their hosts through the outer exoskeleton (cuticle). Fungal spores are picked up on and stick to the insect's cuticle. Fungal spores applied to the environment of the target pest can be taken up through direct impact with the insect or indirectly when the insect is feeding or resting.

Figure 5. House fly infected with M. anisopliae

Mites, beetles, birds and ants

Manure-inhabiting mites can also destroy the eggs and larvae of feedlot flies. Various mites are present on Australian feedlots however their role in limiting fly numbers is largely unknown.

Likewise, ants, beetles and birds are also found in feedlot environments but their impact on fly populations is not known.

Recommended integrated pest management system

Fly populations on feedlots are influenced by many factors such as temperature and rainfall, availability of breeding sites, food resources and abundance and efficacy of natural enemies. 'Normal' fly control is reactive to rapid, and often massive, increases in fly numbers. At this point, insecticides are the only effective control option. If an IPM plan is implemented when fly numbers are low, more benign control tools, such as biological agents, can be used to prevent the occurrence of large fly populations. Figure 6 illustrates the strategies used in feedlots to control nuisance flies.

IPM systems use a range of cultural (mechanical and physical), biological and precisely-focused chemical control methods to reduce pest populations. These methods must be tailored to particular situations and incorporate a range of strategies to provide cost-effective control with minimal insecticide use.

The major components of a fly IPM system are feedlot design, sanitation, biological control and focused insecticide use (Figure 6). The need for, and success of, IPM components is determined by monitoring fly populations.

Key benefits

- More effective control of nuisance and biting flies
- Improved cattle welfare
- Potential production gains
- Better working conditions for feedlot staff
- Reduced risk of disease transmission
- Reduced insecticide use
- Lower risk of insecticide resistance in major fly species
- Lower risk of chemical residues in Australian feedlot beef
- Positive impact on beneficial predators and parasites
- Reduced risk of complaints about flies from neighbours
- Enhanced 'clean and green' image of feedlot industry and associated market benefits
- Reduced negative environmental impact

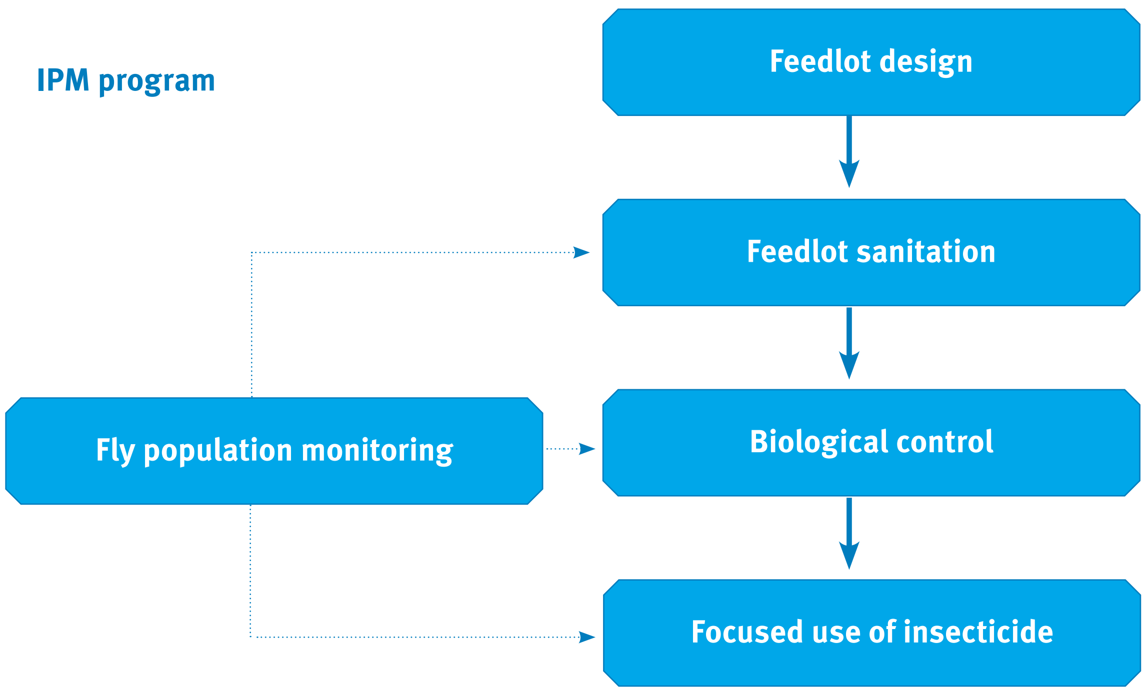

Figure 6. Elements of an IPM program for nuisance flies on cattle feedlot

Feedlot design

Feedlot design can be optimised to facilitate fly control. Most design features will make cleaning and the removal of potential breeding sites easier or more effective. Useful guides to feedlot design are *Design and construction principles* available at www.dpi.qld.gov.au/4789_17260.htm and the *National Guidelines for Beef Cattle Feedlots in Australia*, SCARM Report 47 (2002) available at www.publish.csiro.au/pid/114.htm

Pen foundation and slope

Use appropriate pen foundation construction methods and materials to produce a uniform, durable pen surface that can withstand the loadings from cattle and cleaning machinery without breaking down to form potholes and depressions.

Pen slope should be in the range from 2.5–4% to promote rapid drainage. Good drainage of the pen allows rapid drying of the manure pad after rainfall, while limiting manure transport from the pen area. Pen cross-slope should be less than the pen down-slope to avoid pen to pen drainage.

Feed and water troughs

Use feed and water troughs designed for easy cleaning, preferably with enclosed, vertical sides to eliminate any build-up of spilt feed or manure underneath. They should be equipped with durable aprons (generally concrete) sloping away from the trough to promote good drainage while avoiding pen surface degradation (pothole formation).

Use water troughs designed for easy waste water disposal and cleaning. Shallow, narrow troughs generate less waste water during cleaning. Discharge waste water away from the pen, preferably in a durable surface drain or via an underground sewer pipe, to prevent wet patches forming.

Fences

Widely spaced fence panels (up to 3.2 m between posts) will improve the efficiency of under-fence cleaning. Install the bottom fence cable or wire approximately 400 mm above the constructed pen surface so it is easier to clean under the fence line.

Drains, sedimentation systems and effluent holding ponds

Design drains to carry waste water fast enough to minimise deposition of manure and make cleaning easy. Drains should have either ‘V’ or trapezoidal cross-sections and flat batters. Use a durable base material so cleaning machinery can access the drains as soon as possible after rain.

‘V’ cross-section

Trapeziodal cross-section

Sedimentation basins should also be designed for easy cleaning, with a durable base so they can be cleaned as soon as possible after rain.

Design sedimentation systems and effluent holding ponds so that any vegetation around the perimeter can be mown and/or sprayed.

Manure stockpile and composting area

Manure stockpile and composting areas and carcass composting areas should be established on durable, well-drained earth pads.

Feedlot sanitation

Manure management

Reducing fly breeding sites using cultural (mechanical and physical) methods of feedlot sanitation is a critical element of an IPM program. Flies usually breed in a few, relatively small areas of the feedlot where there is moist manure, spilt feed and silage and mixtures of vegetation and feedlot run-off. Feedlot sanitation for fly control should target these areas.

Manure accumulated under fence lines in cattle pens is one of the major fly breeding areas in the feedlot. Frequent removal of this uncompacted manure will reduce fly breeding. To completely stop fly breeding, this must be done every seven days during summer and less frequently in cooler seasons. Research demonstrates that fly breeding under fence lines can be reduced by 84%, 67% and 55% by weekly, fortnightly and monthly fence line cleaning respectively, compared to no cleaning over three months. Cleaning involves scraping under the fence lines to spread the manure so that it dries out rapidly and is rendered unsuitable for fly development. Cattle pens do not need to be cleaned out as often if adequate stocking densities are maintained to compact the manure and trample larvae.

A similar strategy should be used for the drains and the sedimentation system to minimise the presence of wet manure deposits. Regular cleaning of these areas, particularly after major rainfall events, should occur as soon as the manure becomes workable.

Manure stockpiles must be managed to minimise their suitability for fly breeding. Composting manure in windrows prevents fly breeding because of the high temperatures generated during this process. Align and shape manure stockpiles and composting windrows to avoid run-off water from ponding.

Hospital areas can also be good fly breeding sites due to lower stocking densities, the presence of hay and less frequent cleaning. These areas require frequent cleanouts and the removal of hay spillage on the manure to reduce fly breeding.

Managing other fly breeding areas

Avoid feed spillages where possible and clean up regularly. Feed spills are commonly found near feed bunks, in the feed processing area, in the hospital pens and horse stables. Remove feed spills promptly and add them to composting manure. Do not leave feed residues in bunks for extended periods.

Moist silage provides a suitable substrate for fly breeding. Avoid spills, particularly along the sides of silage pits, and cover the silage pits so that the edges are sealed to reduce fly breeding in this area.

Compost, rather than bury, cattle carcasses. Carcasses have to be completely covered with manure or some other carbon source to prevent blowflies accessing them to breed. With appropriate manure cover, the temperatures in the pile will kill fly larvae and other organisms.

General feedlot maintenance will also contribute to fly control through a reduction in breeding sites and resting places for adult flies.

- Check regularly for water leaks from troughs, as they increase the moisture content of manure pads and facilitate fly breeding.
- Control weeds and keep grass and other vegetation short, particularly around pens, drains, sedimentation systems and holding ponds. This makes it more difficult for flies to find resting places and reduces the vegetation–manure interface, a preferred breeding substrate for stable flies.
- Conduct a thorough feedlot clean-up in early spring, before the start of the fly season to curb fly populations.

Biological control

The primary biological control agents for feedlot flies and their mode of action are described in *Natural enemies* (page 11).

It is important to preserve existing feedlot populations of biological control agents. Most insecticidal fly treatments also kill parasitic wasps and mites so avoid or minimise the use of these treatments. Fly populations recover more quickly than parasitic wasps due to their shorter life cycle, resulting in reduced biological control during this lag period. Biological agents are a softer and slower acting tool for fly control and their use has to be carefully planned and implemented well ahead of major fly waves, unlike some chemical fly treatments.

Keeping fly-breeding substrates (manure, spilt feed and vegetation) dry impedes fly breeding and promotes parasitic wasp and mite breeding.

An additional strategy is to boost the natural populations of parasitic wasps to increase the control achieved by these biological agents. Research demonstrates that releasing the parasitic wasp *Spalangia endius* increases parasitism of fly pupae. This parasitic wasp is commercially available in Australia from Bugs for Bugs (Mundubbera, Queensland). Recommendations for its application in feedlots are provided in *Using parasitic wasps for fly control in feedlots* (pages 18–19).

Fungal biopesticides are another biological tool for fly control. Research demonstrates that fungal biopesticides infect and kill flies in feedlots. Additional research and investment is required to bring fungal biopesticides to market, including registration with the Australian Pesticides and Veterinary Medicines Authority.

Focused use of insecticides

Insecticides can help control nuisance fly populations on cattle feedlots but they should not be the principal strategy. They should only be used if adequately implemented cultural and biological methods fail and a fly monitoring program indicates that a predetermined population threshold has been exceeded. Insecticides should not be used on a scheduled calendar basis, and the following application and targeting guidelines should be considered to avoid unnecessary, ineffective or detrimental applications.

Application

Use larvicides and fly baits in preference to adulticides. Larvicides will not deliver instant relief but will provide better control over time. Research demonstrates that the impact of adulticides is minimal and short-lived.

Using cyromazine (a moulting inhibitor) is recommended over other currently available larvicides because it does not detrimentally affect beneficial insects. For best results, apply cyromazine to recently cleaned areas.

Fly baits are primarily effective against house flies as they contain a house fly attractant. They can be applied either in bait stations, scattered or painted on surfaces. Combining larvicides with fly baits is a successful strategy to delay the development of resistance.

If an adulticide has to be used, residual insecticides are preferred over knockdown insecticides. Knockdown insecticides are short-lived and fly populations are likely to recover quickly after an application. Residual insecticides should be sprayed or painted on major resting sites of adult flies. However, the repeated use of residual insecticides creates a high potential for selection for resistance, particularly if a single product is used. Consult product labels for information on resistance management strategies.

Target areas

Target hot spots rather than broadcast insecticide across the entire feedlot. To control breeding, only apply larvicides to major breeding sites, e.g. pen fence lines, drains, the sedimentation pond and hospital area. To control adult flies, restrict treatments to resting places, e.g. exterior of feed bunks, pen fences, underside of shade cloth, trees and other vegetation. Never apply insecticides to feed or areas that come in direct contact with feed.

Rotation of chemical groups

Rotate the use of chemical groups (Table 1) to prevent the build up of resistance in flies. Repetitive exposure of flies to the same insecticide group results in the development of resistance in the fly population and renders the chemical ineffective.

Only active constituents that are registered for fly control in feedlots, animal facilities, farm buildings or agricultural buildings and included in currently available products are listed in the table. The corresponding products, which are all restricted to non-animal use, can be found on the *Infopest* (2011) DVD or the PUBCRIS database on the Australian Pesticides and Veterinary Medicines Authority (APVMA) website http://services.apvma.gov.au/PubcrisWebClient/welcome.do

Handle and use insecticides according to label instructions. Guidelines for safe and effective use of agricultural and veterinary chemicals are available from the DEEDI website www.dpi.qld.gov.au/cps/rde/dpi/hs.xsl/4790_4906_ENA_HTML.htm

Table 1. List of active constituents and chemical groups that can be used for nuisance fly control in feedlots

Group#	Chemical group	Active constituents	Fly control	Use
1A	Carbamates	Bendiocarb	Adults/larvae	Residual surface/Bait
		Methomyl + Z-9-tricosene	Adult flies	Bait
1B	Organophosphates	Diazinon	Adults/larvae	Residual surface
		Dichlorvos	Adult flies	Residual surface
		Fenthion	Adult flies	Residual surface
		Maldison	Adult flies	Residual surface
		Pirimiphos-methyl	Adult flies	Residual surface
		Trichlorfon	Adults/larvae	Residual surface
3A	Pyrethroids/pyrethrins	beta-Cyfluthrin	Adult flies	Residual surface
		Cyfluthrin	Adult flies	Residual surface
		Cypermethrin	Adult flies	Residual surface
		Permethrin 25:75	Adult flies	Residual surface
		Pyrethrins + piperonyl butoxide	Adult flies	Knock down
4A	Neonicotinoids	Imidacloprid + Z-9-tricosene	Adult flies	Residual surface/Bait
		Thiamethoxam + Z-9-tricosene	Adult flies	Residual surface/Bait
5	Spinosyns	Spinosad	Adult flies	Residual surface
		Spinosad + Z-9-tricosene	Adult flies	Bait
17	Cyromazine	Cyromazine	Larvae	Manure treatment
22A	Indoxacarb	Indoxacarb	Adult flies	Residual surface

Mode of action classification for insecticides Version 7.1 2011 (www.irac-online.org/teams/mode-of-action); list compiled November 2011

Monitoring fly populations

Fly population monitoring is an important element of an IPM program. Information on the identity of the problem species and population fluctuations can provide early warning of fly waves before adult fly numbers escalate. Fly control is more effective if monitoring is implemented before fly numbers increase. Monitoring immature fly populations will give an earlier indication of fly population increase than monitoring adult fly populations.

To keep track of fly population fluctuations and to assess the effectiveness of actions, population monitoring must be regular and systematic. The monitoring system and the site, timing and duration of the monitoring have to remain constant. The results should be assessed immediately after the monitoring period and recorded. Graphing fly counts helps to identify trends in fly populations.

Several monitoring systems for fly populations are available. Adult flies can be monitored by using sticky sheets or traps, or structured observations of fly resting sites or animal behaviour. The extent of fly breeding can be established by inspecting major fly breeding sites.

To improve the consistency of the results, the same person should be responsible for monitoring flies in a feedlot. Some of the monitoring systems are more subjective than others and only a single operator can deliver useful results.

Immature fly monitoring

Monitoring larval populations gives an earlier indication of increases in fly populations than adult fly monitoring. The extent of fly breeding can be established by closely examining manure at major fly breeding sites. Manure needs to be turned over and examined at several locations and a larval rating assigned to each site, e.g. 1 for very low to 5 for very high numbers of larvae. House fly and stable fly larvae can be distinguished by inspecting their posterior spiracles (Figure 2, page 10).

Adult fly monitoring

Sticky sheets

Commercially available sticky sheets retain flies landing on the sheet. They should be placed on vertical walls or posts near preferred fly resting sites, away from excessive dust. Record the species and numbers of flies caught on the sticky sheets over a fixed time. The exposure time of sticky sheets must be chosen to avoid saturation with flies (1–7 days may be appropriate). Major feedlot flies can be identified using the pictorial key (Figure 1, page 9) and a magnifying glass. Sticky sheets are commercially available from Bugs for Bugs (Mundubbera, Queensland) www.bugsforbugs.com.au and Starkeys Products (Wangara, Western Australia) www.starkeys.com.au Alternatively, smaller sticky surfaces such as fly tapes or ribbons can be used although these are less accurate fly monitoring tools.

Traps

Alsynite traps selectively attract stable flies and house flies by reflecting UV light from a cylindrical alsynite panel. They should only be used in open areas. This trap is commercially available from Olson Products (Ohio, USA) www.olsonproducts.com/bite/bite.html

Observations

Fly counts on preferred fly resting sites, such as fence railings, feed bunks, walls or other sites where flies usually congregate, can also be used as a rough indicator of fly populations. This method is less accurate than sticky sheets because counts will depend on the time of day, weather conditions and other variables. It may also be difficult or impossible to identify the fly species present.

Research shows that the number of adult flies in feedlots is closely related to observed cattle behaviour. The number of tail swishes, ear flicks and head tosses observed over a specified time on several animals can be used to gauge house fly and bush fly populations. Likewise, the number of leg stomps correlates well with stable fly populations.

Using parasitic wasps for fly control in feedlots

Biological control agents, such as parasitic wasps and fungal biopesticides, are useful tools for integrated pest management of flies in feedlots. Both occur naturally on Australian feedlots and help control fly populations. Integrated fly management strategies maximise the impact of these agents on flies and releases of mass-reared parasitic wasps can further enhance the effectiveness of this method of control. The parasitic wasp, *Spalangia endius*, is available in Australia from beneficial insectary, Bugs for Bugs, which produces various beneficial insects for use in IPM programs.

What are parasitic wasps?

Parasitic wasps are small (2–3 mm long), black, flying insects that are normally not seen. These wasps affect only flies and are harmless to people, livestock, pets and other animals. Parasitic wasps sting fly pupae and lay their eggs inside. The resulting wasp larvae consume the immature fly, preventing the development of the adult fly. The wasp larvae develop inside the fly pupal cases and emerge as adult wasps after several weeks. One or several wasps can develop inside one fly pupa. Wasps do not emerge from all parasitised pupae as some die before reaching the adult stage however the fly larvae is still killed. Adult wasps also sting and kill fly pupae and feed on pupal contents without laying any eggs.

Spalangia endius wasps can parasitise pupae of many fly species including all common nuisance flies in Australia. They can kill many fly pupae during their adult life. Only one wasp will emerge from each pupae parasitised by *S. endius*.

Releasing parasitic wasps

The mass-rearing of *S. endius* is achieved using the natural host, the house fly. The wasps are sent to users while still inside the fly pupae. Only wasps and no flies will emerge from these pupae, because of the difference in development time. The parasitised pupae are sent to users by express mail and are placed into the feedlot soon after arrival, as the wasp emergence is timed to occur soon after the expected delivery date.

When?

Like all biological control agents wasps will not immediately reduce fly numbers. Their role is to reduce the growth of fly populations. Start wasp releases before fly populations reach undesirable levels. It is recommended that wasp releases begin at the start of the fly season (generally October in southern Queensland) and continue until fly numbers decline due to seasonal conditions.

Fly population monitoring is an important part of integrated fly management. Fly population monitoring will indicate when wasp releases should begin and end. It will also provide an assessment of the success of the wasp releases. Alternatively, knowledge of seasonal fluctuations in fly populations could indicate when to release wasps.

How often?

Spalangia endius wasps live for about 7 to 14 days. Although these wasps breed in feedlot fly pupae, it is necessary to have repetitive and ongoing releases of wasps to achieve optimal fly control. Fortnightly wasp release is generally recommended. Wasps emerge over several days after placement and some of these will still be alive at the time of the next release. Weekly releases would provide a better overlap, but this increases shipping and placement costs. Gaps of more than two weeks between releases result in periods of no wasp activity.

How many?

Recommendations for wasp release numbers vary widely. Releases of 50 to 200 wasps per animal per week are common. In large intensive animal facilities releases of 100 wasps per animal per fortnight are recommended. In smaller establishments or less intensive animal holdings consider a higher release rate (200 wasps per animal per fortnight).

The emergence rate of wasps from parasitised pupae can vary and influences the number of pupa required for an effective release. For instance if the emergence from pupae is estimated at 70% then about 140 parasitised pupae are required for a release of 100 wasps.

Where?

Distribute parasitised pupae across the whole feedlot and place near major fly breeding areas, such as fence lines, sedimentation systems and possibly feed mills. Releasing wasps near fly breeding areas increases the probability of them finding and killing pupae.

Parasitised pupae can be placed in release stations or in protected areas on, or near, the ground. Release stations protect the pupae from heat, direct sunlight and predators such as birds and ants. A simple release station is shown in Figure 7. It was constructed from PVC pipe (diameter 100 mm, 250–400 mm long) with multiple (10–20) round openings (diameter 25–35 mm) covered with fly mesh to prevent pupae from falling out but to allow wasps to leave the container. Use wire or ties to attach these stations to fence posts or rails located close to fly breeding areas (e.g. 200–500 mm above ground) and preferably out of reach of inquisitive animals (e.g. behind watering troughs). Bugs for Bugs also provides release stations suitable for wasps.

Figure 7. Release container for parasitic wasps

Pupae can be mixed with vermiculite (hydrated mineral; Grade 3) in a volumetric ratio of 2:1 to improve ventilation in the release stations and provide additional support and space for wasps to move after emergence. When refilling the release stations, the old fly pupae and vermiculite can be dropped on the ground as both are non-toxic.

Alternatively, pupae can be spread on the ground or into shallow holes but they should be covered with hardened manure to prevent direct sun exposure. Flooding of the pupae by run-off or rain water also needs to be prevented as the wasps will drown if pupae are submerged in water.

Other considerations

Good sanitation is a critical component of integrated fly management. It is essential to frequently remove any substrate suitable for fly breeding, such as wet manure for house flies and stable flies, dung pads for bush flies and carcasses for blowflies. Good drainage will also reduce fly breeding as flies cannot breed in dry substrate. Minimising fly breeding gives wasps a better chance of limiting fly populations by increasing the wasp to pupae ratio.

Use extreme care if insecticide use and wasp releases coincide. Most adulticides and some larvicides also kill parasitic wasps. The larvicide cyromazine or fly baits are the preferred choices, as they are selective for flies.

Additional information

The parasitic wasps *Spalangia endius* can be obtained from Bugs for Bugs, phone 07 4165 4663, email info@bugsforbugs.com.au or www.bugsforbugs.com.au/product/spalangia-fly-parasites

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